San Diego Field Operational Test of Smart Call Boxes
Institutional Issues

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Important institutional lessons learned in the course of the San Diego smart call box field operational test are presented. These lessons relate both to the conduct of the field test itself and to requirements for deployment of intelligent transportation systems similar to smart call boxes. The institutional issues were identified through review of project documents, interviews with participants, and the experience of the evaluator as a participant in the project. Issues were analyzed by preparing summaries that included a description and discussion of each issue, an assessment of its seriousness, identification of the organizational participants who raised it, a discussion of ways to avoid or mitigate any problems identified, and a list of actions to resolve the issue in the event of system deployment. Major institutional lessons include the potential impact of institutional arrangements on basic system concepts, the importance of involving potential users in the definition of system concepts and detailed design specifications, the need for quantitative market research to establish the potential profitability of intelligent transportation systems, the need for an adequate institutional infrastructure for deployment, and the importance of project organization schemes that minimize the number and complexity of formal agreements among participants.

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 authorized the Secretary of Transportation to carry out operational tests related to intelligent vehicle and highway systems. In 1992, FHWA responded by soliciting proposals for a series of field operational tests (FOTs). These FOTs were intended to serve as a transition between research and development activities and full-scale deployment of Intelligent Transportation Systems (ITS). One of the first tests completed under the 1992 program was the San Diego smart call box FOT.

Smart call boxes are devices similar to those used as emergency roadside call boxes in California. The basic call box unit consists of a microprocessor, a cellular telephone transceiver, and a solar power source. The smart call box system also includes field data collection devices such as traffic counters, weather sensors, or video compression devices; call box maintenance computers; and some type of data handling system at a central location, such as a transportation management center (TMC). Figure 1 is a block diagram illustrating the architecture of a generic smart call box.

The purpose of the smart call box FOT was to determine whether smart call boxes are a feasible and cost-effective means of performing specified data processing and transmission tasks. The FOT was divided into five subtests, each focusing on a particular task. These were as follows:

- Traffic census,
- Incident detection,
- Hazardous weather detection and reporting,
- Changeable message sign control, and
- Closed-circuit television surveillance.

A major goal of the FOT evaluation was to identify and analyze institutional issues that either affected the test itself or might affect deployment of smart call box systems. The purpose of this paper is to report on the major institutional lessons learned in the course of the smart call box FOT and to discuss their implications for other ITS development projects. Further information about these institutional issues may be found in the project evaluation reports (*1*,*2*). Technical aspects of the FOT are covered in another paper in this Record and the evaluation reports.

PARTICIPANTS

The smart call box FOT was funded by FHWA and the state of California. It was carried out by a consortium (the FOT partners) of District 11 of the California Department of Transportation (Caltrans), the Border Division of the California Highway Patrol (CHP), and the San Diego Service Authority for Freeway Emergencies (SAFE). The San Diego SAFE is the local agency responsible for providing emergency call boxes in San Diego County.

Day-to-day management of the FOT was provided by a project manager. Initially, the project manager was the Titan Corporation; however, in March 1994 Titan sold this portion of its business to RMSL Traffic Systems, Inc., which acted thereafter as the project manager under subcontract to Titan. On January 1, 1996, RMSL changed its name to TeleTran Tek Services (T-Cubed); in this paper the project manager will be referred to as T-Cubed throughout.

Independent evaluation of the FOT was provided by San Diego State University (SDSU) under subcontract to the California Partners for Advanced Transit and Highways (PATH) program, which served as statewide evaluator for California FOTs.

Technical supervision of the FOT was the responsibility of a regional coordination team (RCT) consisting of voting representatives of the partners and nonvoting representatives of the project manager and the evaluator. In addition, nonvoting representatives of FHWA, the Caltrans Office of New Technology and Research (ONT), and PATH sometimes attended RCT meetings.

Design and installation of test systems were carried out by two vendor teams under contract to the partners. One of these teams was led by GTE Telecommunications Systems of Irvine, California, and the other by U.S. Commlink of San Leandro, California. Input on the management of the FOT by the vendor teams (and, in theory, by any other interested parties) was provided by means of a technical advisory

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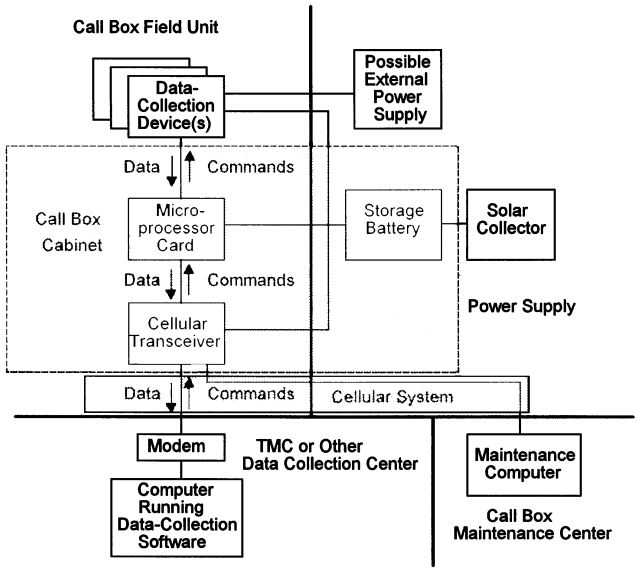

FIGURE 1 Generic smart call box system architecture.

committee (TAC). Figure 2 is a schematic diagram showing the formal lines of authority and reporting among the participants.

EVALUATION METHODOLOGY

A major evaluation objective was to identify and analyze the institutional issues encountered. Goals of this portion of the evaluation were to determine the perceptions of participants regarding the institutional aspects of the FOT and to identify and analyze institutional issues likely to affect the deployment of smart call boxes. This analysis was based on information obtained from documentary sources, interviews with participants, and the experiences of the evaluator as a participant in the FOT. Documents reviewed included contracts and agreements, progress reports, project diaries, correspondence among participants, notes of meetings of the RCT and the TAC, and the FOT evaluation documents, including the evaluation plan and individual test plans. Participants in the FOT were interviewed either in person or by telephone to determine their opinions about institutional issues. Interviews with local participants who were heavily involved in the FOT were conducted in person; those with out-of-town participants and local participants with less involvement were conducted by telephone. Typed summaries of interviews were prepared and mailed to the subjects, who were asked to review the summaries and verify their accuracy. In addition, some institutional issues were raised directly by the evaluator.

Analysis of institutional issues consisted of preparation of detailed summaries for each issue that was considered significant. These include a description and discussion of the issue, an assessment of its seriousness, identification of the organizational participants who raised it, a discussion of ways to avoid or mitigate any problems identified, and, for issues related to system deployment, a list of actions required to resolve the issue in the event of deployment.

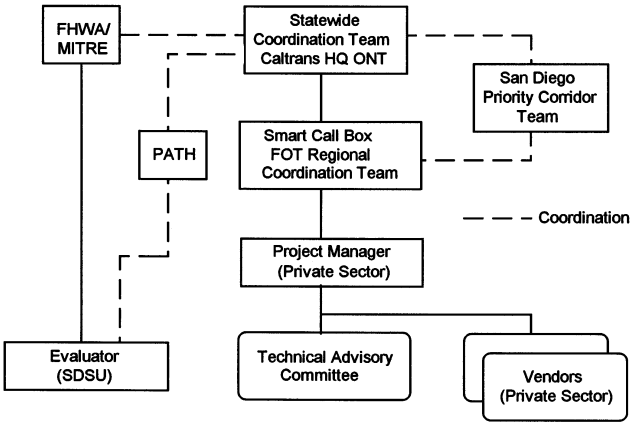

FIGURE 2 Formal lines of reporting for the smart call box FOT.

ISSUES

The smart call box FOT was primarily a system development effort. That is, although the test systems were constructed using existing components, these components had not previously been integrated as a unit to perform the functions included in the test. Important requirements for successful deployment of the end products of development efforts of this type are the following:

1. A product that meets users' needs. This implies that the end product is based on a valid system concept, meets the requirements of potential users, and is ready for deployment.
2. Adequate incentives for producers. This implies that the potential market for the end product must be large enough, potential profit margins must be adequate, and there must be no major institutional barriers to marketing the product.
3. Institutional infrastructure capable of deploying the product. In the case of products that are intended primarily for use by public agencies (such as smart call boxes), there must be a public-sector institutional system capable of organizing and financing procurement, a private-sector industry capable of producing the product, and a procurement process that links the two.

Other institutional issues related primarily to the efficiency of the development process itself. This will often have an indirect impact on the success of deployment, because an efficient development process is more likely to lead to a finished product in a timely manner at a reasonable cost. To be efficient, the development process must involve efficient administration, effective internal organization, and appropriate incentives for participants.

Issues Related to Fulfillment of Potential User Needs

Effect of Existing Institutional System on Selection of System Concepts

The smart call box FOT was a product of the existing institutional system for providing voice call boxes in California. This system is locally controlled and highly privatized. It is based on special-purpose, county-level SAFEs. These are funded by a surcharge on vehicle registration fees that is imposed on a county-option basis. The SAFEs contract with a private consulting firm to manage the system and with private-sector vendors to provide, install, and maintain call boxes. In most cases, SAFEs own the call boxes, although some are provided under lease-purchase agreements with the

vendors. In addition, Caltrans and CHP are involved in operation of the call box system.

The FOT proposal was written by employees of T-Cubed (then Titan Corporation), the call box management consultant for all the California SAFEs and the eventual project manager. The project initially was promoted by T-Cubed and the San Diego SAFE, which solicited involvement by the local Caltrans district and the local CHP division. The FOT partners were thus the local version of the statewide partnership for providing call boxes, and the proposal represented primarily the thinking of the statewide call box consultant.

Largely as a result of this institutional background, the FOT always was defined as exploiting and extending the capabilities of existing call box technology rather than seeking the best solutions for the data processing and transmission tasks involved. The test was conceived as a comparison of smart call box systems with baseline systems involving hardwire telephone communications rather than a comparison of different ways of providing wireless data collection systems.

Other wireless system concepts were certainly possible. They would have involved somewhat different technical approaches but, more important, would have implied a different set of participants. For instance, one competing system concept is to equip an existing traffic counter or weather sensor with solar power and a cellular modem, and have it communicate directly with data collection software installed at some central location such as a TMC. This particular configuration does not employ a call box and logically would be developed by a traffic counter or weather sensor vendor rather than a call box vendor.

Hence, the range of system design concepts compared by the FOT was limited by the interests of the institutional system that proposed it. This institutional factor had a profound influence on the technical aspects of the FOT and will have a major impact on the viability of the products developed through it.

Compatibility of System Designs with Transportation System Management Needs

Successful system deployment depends not only on sound system concepts but also on detailed product designs that are well suited to the needs of potential users. Consequently, it is important that potential users and other interested parties be involved in the development of test system specifications. The systems developed by the smart call box FOT were intended to be used by traffic planning, traffic operations, and TMC personnel nationwide.

Four groups participated in the development of test system specifications: (*a*) local Caltrans operational personnel, who were potential system users; (*b*) the project management team consisting of the RCT, the project manager, and the evaluator; (*c*) the vendors; and (*d*) the sponsoring agencies, such as FHWA and the Caltrans ONT.

Each of these groups had a somewhat different perspective. Local Caltrans operational personnel were concerned that test systems serve specific existing needs and tended to favor conservative designs that might not be geographically transferable. The project management team was concerned with developing a wide range of call-box-based technology but was still looking for systems that could be implemented locally. The vendors presumably were interested in developing systems that could be marketed on a nationwide basis but also were concerned with producing workable systems within the time and resource constraints of the FOT. The sponsoring agencies were interested in "interesting" technical applications and transferable results. Needless to say, all these somewhat conflicting goals could not be met.

Effective control of the FOT lay with the project manager and the RCT. Local Caltrans operational personnel had input on the FOT through participation in the TAC and through formal performance standards, which were developed by the evaluator in consultation with them and then adopted by the RCT. The performance standards, however, were finalized late in the process of developing vendor proposals and may have had little impact on them. The vendors provided the detailed system designs under the oversight of the project manager. The vendors also participated in negotiations with the RCT and the project manager that helped define the scope of the FOT and the underlying system concepts. The sponsoring agencies had little input into test system specifications. Also, there was no formal mechanism for incorporating input from operational personnel outside the San Diego area.

Test system specifications might have been improved by careful consideration of ways to solicit input at an early stage in the FOT. Ideally, a series of discussions involving all interested parties would have been held before issuance of a request for participation (RFP) to potential vendors. The goals of these discussions would have been to identify the scope of the test and to clarify issues related to the feasibility of proposed system features and their compatibility with TMC operations in a variety of geographical areas.

Requirements for Further Development and Testing

To be available for immediate deployment, test systems must be in a finished state at the end of the development process. It had originally been intended that the FOT would not only demonstrate the functionality of the test systems but also evaluate their reliability and cost-effectiveness. Because of schedule slippage, the incident detection test systems were never developed to the point that they were functional. Other test systems appear to have functioned correctly but could not be observed for adequate periods to establish their reliability or to estimate their potential maintenance costs. Still others functioned correctly, to established performance standards, but will require further development to be useful in a TMC setting. As a result, all the test systems involved in the smart call box FOT will need further development and extensive testing before deployment.

This lack of a finished product was in part due to deliberate decisions that limited the scope of the FOT. Early in the process of planning the test, it was decided to focus on development and testing of field portions of the systems rather than on TMC data handling and display systems, even if these might be required to make the overall system useful. For the most part, however, test systems were left unfinished because of unanticipated delays resulting from miscalculations of the technical difficulty of design tasks, the administrative inefficiency of the sponsoring agencies, and an awkward organizational structure. Details of these problems are discussed in the following sections, along with other institutional factors affecting the efficiency of the FOT.

Issues Related to Producers' Incentives

Market Size and Potential Profitability

If smart call boxes are to be deployed successfully, it must be possible to produce them profitably. The prospects for doing so depend

on the size of the potential market and the profit margin per unit. No attempt was made to estimate the total size of the market for smart call boxes as a part of the FOT. It appears, however, that the market for smart call boxes will be small compared with that for many other types of electronic equipment. At present, the call box market is mature, with multiple vendors competing on cost, and profit margins are modest.

Smart call boxes would have to interface with a wide range of intelligent data-collection devices with (perhaps) radically different interface requirements. Each new data-collection device is likely to require substantial nonrecurring engineering (NRE) costs, which will increase the cost of each unit. This will be a continuing problem, arising every time any component of the system is altered. The viability of the smart call box concept can be greatly enhanced by development of standards for communications protocols for devices communicating with smart call boxes. Development of such protocols and adherence to them by vendors of intelligent data-collection devices are unlikely unless the market for smart call boxes is adequate for vendors to recover their NRE costs.

The vendors that participated in the smart call box FOT have expressed interest in pursuing further development of several applications, but also have expressed reservations about some of the test applications based on perception of the potential market size. Although further development of the smart call box concept is a matter for potential vendors to decide, quantitative estimates of market potential are advisable before significant investment in additional development.

Intellectual Property Rights

One potential barrier to deployment of systems developed by public-private partnerships is ownership of intellectual property. Since system development is partly funded by the public sector, public agencies may gain rights to the resulting systems. This can inhibit further development and marketing of the systems by the private sector, either because property rights are not defined clearly or because potential profits are diminished by the need to pay royalties. This potential problem was recognized in the planning of the FOT, and, as a result, the RCT deliberately avoided acquisition of intellectual property rights. This policy was intended to leave the vendors free to develop their systems on a proprietary basis and to encourage vendors to continue development and marketing after expiration of the FOT.

Issues Related to Institutional Systems for Deployment

Public-Sector Institutional Structures

A prerequisite for successful deployment of smart call boxes is a public institutional system capable of financing and procuring them. In California, the most likely scenario for deployment is a minor modification of the existing SAFE system for provision of voice call boxes. In this scenario, both smart call boxes and regular call boxes would be owned by the SAFEs, although other agencies might contribute to their financing. Figure 3 illustrates this institutional system. A possible exception exists where smart call boxes are used for data transmission only. In this case, there is no compelling reason for smart call boxes and regular call boxes to be under the control of the same agency, and the smart call boxes may be owned by Caltrans or by local agencies.

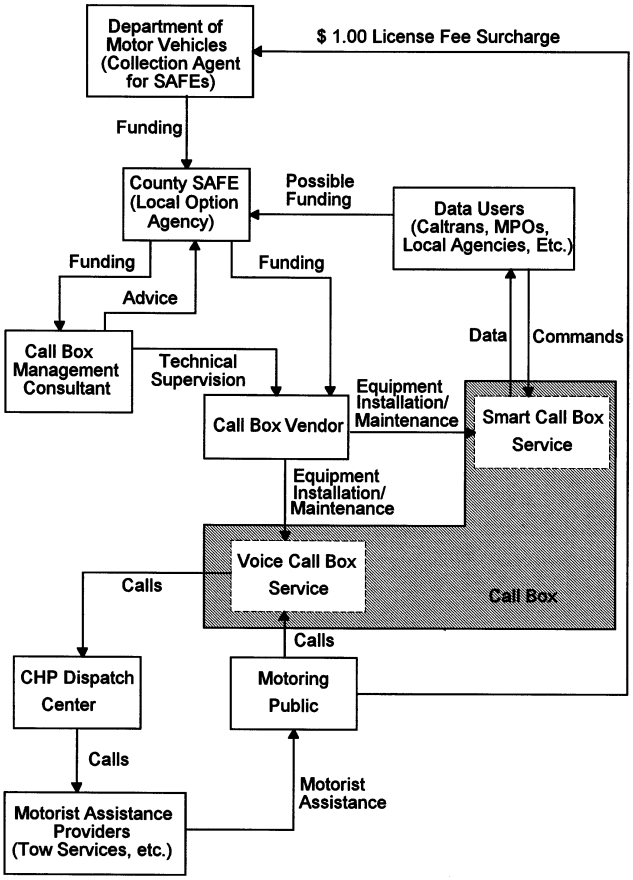

FIGURE 3 Possible institutional arrangements for smart call boxes in California.

Outside California, it is most likely that state transportation departments or local governments will own smart call box systems, whether they function as data-collection devices only or as combined voice and data transmission systems. Another possibility is for vendors to retain ownership and to lease smart call boxes to public agencies. This arrangement is already used in California for some voice call box systems.

Successful deployment also depends on funding sources adequate to cover life-cycle costs. In California, it may be possible to fund smart call boxes locally, using funds administered by the SAFEs. The viability of this method is not ensured, however, since it depends on the willingness of the local SAFEs to provide funding for system costs that are of benefit primarily to the users of the data. Their willingness to do so is likely to depend on the extent to which there is adequate funding for voice call boxes and the other motorist assistance services they administer. The adequacy of the current funding source varies geographically because it depends on population density. Reliance on local funding in California could lead to a situation in which deployment of smart call boxes may be based more on the availability of funding than on cost-effectiveness. Outside California and in areas in California for which SAFE funds are not available, other funding sources will be required.

An additional issue related to ownership and financing of smart call boxes is ownership and distribution of the data they produce. Potential users include state departments of transportation, local agencies, metropolitan planning organizations, and private-sector

firms involved in advanced traveler information systems activities. Even within state departments of transportation, smart call boxes may be associated primarily with TMCs, but the data produced by them are likely to be used by other units. Arrangements, both physical and institutional, must be worked out for the distribution of data and any corresponding payments to be made by data users.

Private-Sector Institutional Structure

Successful deployment of smart call boxes requires the existence of private-sector firms with the technical ability and the financial incentive to provide them. The electronics industry involved in the provision of call boxes consists of several very small vendors engaged in highly specialized lines of business. These vendors usually are subsidiaries or divisions of large parent firms. Ownership of these small units tends to change frequently; in addition, because they are small and specialized, they are heavily dependent on subcontracting to obtain engineering services outside their own areas of expertise.

The project manager, which had three corporate identities during the life of the project, was the most obvious example of the revolving-parent-firm phenomenon in the FOT. In this case, the corporate identity changes had virtually no impact on the conduct of the test.

In another case, however, a conflict between one of the prime vendors and a principal engineering subcontractor seriously affected the vendor's performance. This conflict eventually resulted in the subcontractor's acquiring the prime vendor's call box business, although this did not take effect until after the end of active work on the FOT. In another case, one of the prime vendors had such severe cash flow problems that work on the FOT was sometimes halted when payments were late; in part, this may have been a result of inadequate support from the parent firm. Also, there was evidence of lack of communication within one of the vendor teams. In this case, some of the equipment suppliers reported that they were informed of important test requirements at the last minute or that they were unaware of test results involving their products.

In a deployment environment, these problems could have a serious impact. Those related to cash-flow problems are likely to be worse in a normal government procurement environment than they were in the FOT. Because procurement for the FOT was administered by the San Diego SAFE, it was exempt from normal state procurement regulations. It was the opinion of several of the participants that, as a result, the FOT was exceptionally prompt in paying the vendors. In addition, the performance of deployed systems clearly could be damaged by lack of communication between prime contractors and subcontractors or conflicts between vendors and subcontractors leading to loss of engineering support.

Procurement Practices

Emergency call box systems in California are managed by a private-sector consultant and installed and maintained by vendors. The most likely model for procurement of smart call boxes in California is a similar system, although others have been proposed and may be attempted. Outside California, procurement models may be quite different. For example, state transportation departments may manage smart call box systems directly and use their own employees to perform maintenance, possibly installation. Various combinations of these two models also are possible. Institutional issues and problems will vary depending on the model chosen.

The California procurement model requires minimal public staffing and may result in expert and efficient management and maintenance. In addition it allows for more flexibility in funding arrangements and procurement policies and may provide a greater incentive to vendors to supply reliable equipment, since the vendors also maintain it. Direct public operation, on the other hand, provides public agencies with greater control over system management and, by avoiding outside contracts, reduces overhead costs and the delay, expense, and inconvenience involved in processing contracts.

Both procurement models may encounter system compatibility issues if there are several vendors. Current procurement policies commonly result in an exclusive relationship between a public agency and a single vendor. Introduction of smart call boxes into an existing voice call box system may disrupt this relationship because the system owner may favor one vendor's voice call box and another vendor's smart call box.

Careful planning may be required to avoid potential problems if more than one vendor is to be used in a given geographical area. If maintenance is provided by the vendors, there may be problems with responsiveness if the number of units provided by a vendor is too small to warrant a resident maintenance staff. If maintenance is provided in-house, it may become more complicated and expensive because of the proliferation of devices to be maintained. Also, maintenance computers are used to monitor call boxes and it may be necessary to provide separate monitoring systems, since monitoring software varies among vendors. Finally, if the products of more than one vendor are used for the same data-collection function, separate software packages and possibly separate computer systems will be required for data collection at the TMC.

Another procurement issue is that of contracts with cellular carriers. In California, existing contracts between SAFEs and cellular carriers provide for service at a major discount compared to that offered to the general public, but may cover voice communications only. Use of smart call boxes requires contracts covering data communications; this may require renegotiation of some existing contracts. The details of such contracts may have a significant effect on the cost of providing smart call boxes.

Issues Related to Efficiency of Development Process

Administration

Efficiency in the administration of a development process such as the smart call box FOT involves timely decision making and prompt and accurate performance of administrative functions such as processing contracts and agreements, processing claims for payment, and issuing payments to vendors and other participants.

The San Diego SAFE was chosen as financial agent for the FOT largely because it is exempt from normal state procurement regulations. Where administrative functions were completely under the control of the San Diego SAFE, they proceeded with reasonable speed. On the other hand, there were major delays in negotiating and processing the interagency agreements funding the FOT and its evaluation. In this case, much of the delay was due to the extremely cumbersome procurement procedures of the state of California and to the fact that Caltrans failed to process the separate FOT and evaluation contracts simultaneously.

There were also delays in issuing vendor contracts that resulted from extensive contract negotiations. One problem was that much of the language in the original draft contracts was based on county

of San Diego standard agreements. The vendors considered some of this language inappropriate for an operational test. At the same time, there was the difficult problem of devising language that would adequately protect both the vendors and the FOT partners. This issue will be discussed in more detail later.

Project Organization

Major organizational features of the FOT included technical control by the RCT, use of the San Diego SAFE as the financial agent, use of a hired consulting firm to provide day-to-day project management, an arms-length contractual agreement with the vendors, and an independent evaluator. These features resulted in a fairly complicated set of contractual relationships, as illustrated in Figure 4. The use of the independent evaluator was required by the national FOT program, but the other key features of the project's organization were decided locally. Some of these were rather unusual. For instance, this was the only FOT in California to be controlled locally instead of by the Caltrans ONT; also, the use of a private-sector project manager was unusual.

Many participants in the FOT considered local control and involvement of a private-sector project manager to be organizational strengths. These features were believed to have strengthened the organization and direction of the project and to have led to its early completion. However, at least one representative of the ONT believed that local control weakened the FOT's technical accomplishments. In addition, representatives of the sponsoring agencies stated that use of a private-sector project manager was expensive. Some expressed concern that T-Cubed might have pursued its own interests in the development of call box technology at the expense of options that would have been more beneficial to Caltrans.

A more important issue related to the role of the project manager arose because T-Cubed did not define its own role in the FOT proposal that it wrote on behalf of the public partners. Instead, the formal selection of the project manager was by means of a competitive process, which eventually resulted in the selection of T-Cubed. This created an awkward situation. T-Cubed clearly wrote the proposal with the hope of being named project manager, and in doing so had donated services to the public partners for which it had the right to expect some return. Moreover, it had an overwhelming advantage in the competitive selection process because of its familiarity with the details of the project. Conversely, some members of the SAFE Board of Directors believed that it might constitute a conflict of interest to award a project management contract to a firm that had proposed the project in the first place. The entire episode created unnecessary uncertainty and might have been avoided had the proposal included the project manager as a partner.

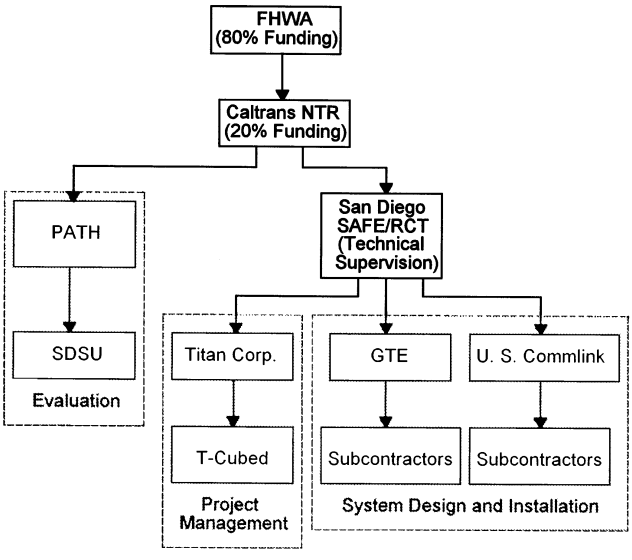

FIGURE 4 Contracting structure for smart call box FOT.

Use of an independent evaluator was mandated by FHWA. The intent of this requirement was to ensure the objectivity of the evaluation. At the same time, it had negative effects on the efficiency of the project and the effectiveness of the evaluation. Separation of the evaluation contract from the FOT contract created a source of delay, since Caltrans did not process the evaluation contract until after the FOT agreement was finalized. Serious delay was averted only because the evaluator began work without a contract. More important, evaluation issues were neglected in the early stages of project planning because the evaluator was not involved in the development of the FOT proposal. Later, when it came time to produce the evaluation plan, it sometimes was difficult to redirect the FOT so that it focused on clearly defined issues that could be evaluated.

The decision to include vendors through arm's-length contractual arrangements rather than as full partners also had a serious effect on the efficiency of the project. This led to a time-consuming vendor-selection process, which included issuance of an RFP, preparation of proposals by the vendors, review of these proposals by the RCT, negotiations between the RCT and the vendors concerning technical issues and the scope of the test, and negotiations over contract language. In all, these activities consumed more than a year, and resulted in predictable vendor selections. Moreover, the realism of some of the items included in the FOT proposal was questionable, and inclusion of the items may have been avoided by involving prospective vendors from the beginning.

The vendor selection process not only was time consuming but also may have had a negative effect on the vendors' subsequent performance. The RFP suggested that more than one vendor might be selected but did not clearly state that the RCT might elect to fund both prospective vendors for all subtests. When this happened, funding available to the vendors was reduced to approximately half that requested, but the system engineering effort required was not reduced proportionately. As a result, insufficient resources were available for engineering, which contributed to schedule slippage.

Risks and Incentives

Product-development projects carried out by public-private partnerships require an equitable distribution of risks and incentives. Project agreements need to provide private-sector participants with incentives to give their best efforts without holding them responsible for product failures that may be a legitimate outcome. In the case of the smart call box FOT, this issue was repeatedly encountered in contract negotiations between the RCT and the vendors and in the subsequent enforcement of those contracts.

The most important issue had to do with adherence to schedules. Project schedules were included by reference in vendor contracts and, initially, proposed contract language included a provision for liquidated damages in the event deadlines were not met. This provision was deleted after both vendors objected that the amount of system integration involved in the project created a level of

uncertainty that was incompatible with it. This left the RCT in the position of relying on provisions providing for inspections to ensure the timeliness and quality of work. GTE also requested a number of changes in these provisions, including language to the effect that failure to complete any and all tasks, using best efforts, should relieve the vendor from further financial responsibility. The RCT, on the project manager's recommendation, insisted that "best effort" be defined as completing the scope of work outlined in the contract within the time allotted by the schedule.

Once contracts were in place, the vendors failed to adhere to the contract schedules. From the point of view of the RCT and the project manager, it was unclear whether the delays were due to unexpected technical difficulties or to inadequate effort. However, it was clear that delays in installing field equipment were jeopardizing the FOT evaluation by reducing the time available to collect data. This situation became so serious that at one point the RCT issued notices to cure default to both vendors.

The real problem with the schedules was not so much the contract language, however, as the RCT's reluctance to enforce it. For instance, several of the firm deadlines established by the cure notices were violated without any real consequences. The RCT was trying to maximize the FOT's contribution to the development of smart call box technology and was thus reluctant to cancel subtests as long as there was hope that they would succeed, although this compromised the evaluation of system reliability.

CONCLUSION

The smart call box FOT involved a public-private partnership to develop and test ITS devices—in this case, smart call box systems. The experience of this FOT can provide valuable institutional lessons to other ITS development projects. Following are some of the most important lessons.

1. Institutional arrangements can have an important effect on the technical characteristics of ITS products developed through projects similar to this one. Institutional biases can affect both basic system concepts and design details. In the case of smart call boxes, it appears that the system concept is feasible but not necessarily optimal. Also, it is important for product development projects to involve potential users in the definition of both system concepts and detailed specifications.
2. ITS devices will be deployed only if it is profitable for someone to produce them. Research leading to quantitative estimates of market size should be undertaken early in the development process. This was not done in the case of smart call boxes. Although both potential users and potential vendors remain interested in the concept, quantitative market research should be undertaken before significant additional investment in smart call boxes.
3. Successful deployment also requires an adequate institutional infrastructure for both production and use. In the case of smart call boxes, a prototypical institutional system for deployment exists in California, but not elsewhere in the United States. Even in California, it is not entirely clear how the system for providing emergency call boxes must be adjusted to accommodate smart call boxes. Agencies considering deployment of smart call boxes (or other ITS devices) must prepare careful deployment plans outlining financial arrangements, organizational responsibilities, procurement processes, and integration of the resulting data into their operations.
4. The efficiency of ITS product development projects depends on administrative and organizational efficiency and equitable distribution of risks and incentives. Because public agency procurement processes usually are cumbersome and time consuming, it is probably best in most cases to organize projects to minimize the need for contracts among the participants. This usually will mean that all significant participants should be included as partners in the initial proposal. The proper distribution of risks and incentives, especially where project coordination and scheduling are concerned, is apt to remain a difficult question regardless of organizational structure.

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